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Sampling and Analysis Plan for Groundwater Sampling and Well Installation in the Solar Ponds Plume Area

RMRS Rocky Mountain Remediation Services L.L.C
protecting the environment

RF/RMRS-97-136

Environmental Restoration
Rocky Flats Environmental Technology Site

Revision 0

Sampling and Analysis Plan
for Groundwater Sampling and Well Installation
in the Solar Ponds Plume Area

February 10, 1998

Prepared by

Rocky Mountain Remediation Services, L.L.C.

Rocky Flats Environmental Technology Site

Golden, Colorado

John E. Fan for John Hopkins

Responsible Manager

Gregg D. [illegible]

Quality Assurance

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TABLE OF CONTENTS

1.0 INTRODUCTION

The Solar Ponds Plume (SPP) is an area of groundwater contamination which extends from the Solar Evaporation Ponds (Solar Ponds), in the northeastern corner of the Industrial Area, to the northeast toward North Walnut Creek and to the southeast toward South Walnut Creek (Figures 1 and 2) The primary contaminants of concern are nitrate/nitrite and uranium isotopes ($U^{233\ 234\ 235}$ and U^{238}), however, other inorganic and organic compounds have also been identified above the Tier II Action Levels in some wells

The Rocky Flats Cleanup Agreement (RFCA) among the Rocky Flats Environmental Technology Site (RFETS), the U S Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE) set a milestone of fiscal year 1999 for implementation of a remedial action which would control the contaminated groundwater in the SPP and prevent it from causing North Walnut Creek to exceed the in-stream standards (DOE 1996)

As an initial phase in determining the appropriate remedial action, RMRS undertook a study to evaluate alternatives for management and treatment of the water collected by the Interceptor Trench System (ITS), which collects the SPP before it reaches North Walnut Creek (*Solar Ponds Plume Remediation and Interceptor Trench System Water Treatment Study*, RMRS/RTG, September 1997) The objective of the study was to determine a permanent remedy for the SPP Eleven alternatives were evaluated and four alternatives were retained for further study The report identified a more detailed site characterization as one important component necessary to complete a more detailed evaluation of the retained alternatives

This detailed site characterization will be accomplished through the following steps

1 Collection of additional groundwater samples from all of the wells in the Solar Ponds area which contain sufficient water and analyze these samples for dissolved uranium isotopes and nitrate/nitrite This data will allow definition of the nature and extent of the SPP, as well as comparison of the water quality in the three stratigraphic units identified in the area alluvium, weathered bedrock, and competent bedrock

2 Compiling a detailed site hydrogeological model using all available data from site-specific and site-wide studies

3 Developing a groundwater flow model which incorporates the new site conceptual model and can be used to predict the effect of the various alternatives on North Walnut Creek

Although there are many wells in the SPP area and a large amount of water quality data has been collected over the years, particularly nitrate, all of the wells have never been sampled for the same analytical suite during one sampling event The purpose of this Sampling and Analysis Plan (SAP) is to define the groundwater sampling and well installation activities to be conducted for characterization of the groundwater quality in the three stratigraphic units in the SPP area Installation of five additional groundwater monitoring wells in three areas of the SPP is proposed to fill in missing data in the alluvium or weathered bedrock units or to replace previously-installed wells that have been destroyed A Geoprobe ™ will be used to install the new monitoring wells

The objective of this SAP is to describe the specific data needs of this groundwater sampling event, as well as the sampling and analysis requirements, data handling procedures, well construction criteria, and associated Quality Assurance/Quality Control (QA/QC) requirements for this project All work will be performed in accordance with the RMRS Quality Assurance Program Description (QAPD) (RMRS 1997) The SAP summarizes the existing data and describes the procedures to be used in installation of the monitoring wells and collection of the groundwater samples

1.1 Background

The Solar Evaporation Ponds (Solar Ponds) are located in the northeastern corner of the Protected Area The five ponds were used to store and evaporate radioactive process water from the 1950s to 1986 Cleanup activities began in 1985 to drain and remove sludges from the five ponds and the Building 788 Clarifier The intent was to process the sludges to produce "pondcrete" blocks, which would be shipped to the Nevada Test Site for disposal Difficulties in the pondcrete solidification process, as well as disposal of the pondcrete blocks (tests showed that the pondcrete contained hazardous constituents which rendered it a mixed waste), resulted in cessation of shipments of pondcrete to NTS in 1990 Approximately 10,000 cubic yards of pondcrete remain at RFETS In 1993, the remaining sludges were collected via vacuum trucks and contained in 66 10,000-gallon capacity storage tanks These tanks are currently stored on the 750 Storage Pad Additional remediation activities to remove contaminated soils, equipment, and structures are proceeding In the Focus on 2006 plan for RFETS (Kaiser-Hill 1997), capping was selected as the ultimate remediation for the Solar Ponds and vicinity, and is expected to be completed in Fiscal Year 2005

The Solar Ponds Plume, or SPP, emanates from the ponds The SPP is being evaluated separately from the Solar Ponds themselves The primary contaminants of the SPP are nitrate and uranium The plume extends northward from the Solar Ponds to North Walnut Creek and to the southeast, towards South Walnut Creek Volatile organic compounds (primarily trichloroethylene [TCE], tetrachloroethylene [PCE], carbon tetrachloride [CCL_4], 1,1-dichloroethylene [1,1-DCE], and chloroform) have been detected in wells located in the area of the western Solar Ponds and to the southeast of the Solar Ponds This VOC contamination is not thought to have originated at the Solar Ponds, but from source areas to the west and southeast Exceedances of the RFCA groundwater action levels for several metals have also been detected

An Interceptor Trench System (ITS) was installed in 1971 and expanded in 1981 to prevent the SPP from reaching North Walnut Creek This system of trenches and drains traverses the hillside to the north of the Solar Ponds and collects both surface water infiltration and groundwater The ITS was installed in the unconsolidated alluvium and is not keyed into bedrock The ITS effectively dewaters the alluvium in this area, however, contaminated groundwater in the weathered bedrock directly below the alluvium may continue movement toward North Walnut Creek Since 1993, water collected by the ITS has been transferred to three modular storage tanks (MSTs), where it is stored prior to evaporation at Building 374 The cost of treatment at Building 374 is approximately $2 per gallon, 2 to 3 million gallons of water are treated each year

1.2 Evaluation of Remedial Alternatives for SPP

In 1997, RMRS undertook a study to evaluate alternatives for management and treatment of the water collected by the ITS (RMRS/RTG, September 1997) The objective of the study was to determine a permanent remedy for the SPP Eleven alternatives were evaluated and four alternatives were retained for further study 1) Managed release of ITS water to Pond A-4, 2) Treatment of ITS water at Building 995,

3) Phytoremediation, and 4) Enhanced Evaporation of ITS water at the MSTs Enhanced Evaporation has been eliminated from further study, due to concerns of windblown dispersion during the spraying operation used for the evaporation of the ITS water

As discussed earlier, final evaluation of the retained alternatives requires a detailed characterization of the water quality in each stratigraphic unit, a refined conceptual hydrogeological model, and a site groundwater flow model These models can be used to predict the concentrations of nitrate, uranium, or other contaminants in the groundwater that will discharge to North Walnut Creek once RFETS has been closed and the ITS is no longer used to collect the SPP water The current and planned field activities (discussed in Sections 2 and 3 of this SAP) will collect the data necessary to complete the conceptual hydrogeological model and site groundwater flow model, as well as evaluate the three retained remedial alternatives

1.3 Site Conceptual Model

The Solar Ponds are located on level ground in the northeastern portion of the Protected Area The subsurface geology beneath the SPP consists of surficial deposits underlain by weathered/fractured bedrock and competent bedrock (claystone)

1.3.1 Surficial Deposits (Alluvium)

The surficial deposits in the Solar Ponds and SPP areas consist of Rocky Flats Alluvium, landslide deposits, colluvium, valley-fill alluvium, and artificial fill These materials uncomformably overlie the Arapahoe Formation bedrock The Rocky Flats Alluvium, composed of clay, silt, sand, and heterogeneous pebbles, cobbles, and boulders, underlies the Solar Ponds Artificial fill and colluvium are found together in the ITS area and to the southeast of the Solar Ponds Valley fill alluvium, composed of clay, silt, sand, and pebbly sand with silty and cobbly gravel lenses, is found in the Walnut Creek drainages (DOE 1995) Hereafter, the surficial deposits will be referred to as "alluvium "

The alluvium thickness ranges from 1 to 22 5 feet in the vicinity of the Solar Ponds and the SPP The thickest areas of alluvium are found to the northeast (near well 46393) and southeast (near well P219489) of the Solar Ponds (DOE 1995) Bedrock unconformably underlies the surficial deposits and consists of weathered claystone and minor sandstones of the Cretaceous Arapahoe and Laramie Formations (DOE 1995, EG&G 1995b)

Ground water flow enters the Solar Ponds area from the west-southwest in the alluvium and weathered bedrock Groundwater flows eastward beneath the Solar Ponds and then diverges to the north-northeast toward North Walnut Creek and to the east-southeast toward South Walnut Creek This divergence in groundwater flow is caused by an east-west trending bedrock high beneath the Solar Ponds and natural topographic breaks in these directions (DOE 1995)

The groundwater flow path is very complex due to the varying thicknesses of the alluvium and weathered bedrock units and the highly variable primary and secondary permeabilities of the two units The combination of the varying thickness of the alluvium and seasonal water table fluctuations result in large areas of the alluvium becoming unsaturated The lateral groundwater flow direction in the competent bedrock is not well defined The hydraulic gradient is downward between the alluvium and weathered bedrock in the vicinity of the Solar Ponds due to infiltration of rainfall at the ponds, but appears to be upward in the vicinity of North and South Walnut Creeks, based on limited data (DOE 1995)

The hydraulic conductivity of the alluvium ranges from 10^{-8} to 10^{2} cm/sec (3 0 x 10^{-4} to 3 0 x 10^{2} feet/day), with the higher values attributed to valley fill and alluvium, and the lower values attributed to the Rocky Flats Alluvium (EG&G 1994) The typical hydraulic conductivity for Rocky Flats Alluvium was on the order of 10^{5} cm/sec (3 0 x 10^{1} feet/day)

1.3.2 Bedrock

The bedrock beneath the SPP is composed of claystone and silty claystone, with sandy siltstone and lenticular sandstone bodies The claystones and siltstones are likely part of the Laramie Formation, while the sandstones are more likely part of the Arapahoe Formation Claystone is the predominate lithology in the study area described in this SAP The bedrock lithologies have been variously altered by weathering Weathering-induced fractures and fracture fillings in bedrock claystones and siltstones have increased the permeability of these units and have imparted an additional degree of friability on coarser-grained sandstone units (DOE 1995)

Claystone

Claystones are the most common bedrock lithology in the SPP area They often contain a significant amount of silt, but are sometimes pure clay Fractures identified in the SPP area occurred 10° to 40° from the horizontal and commonly contained caliche or iron oxide (DOE 1995) Fractures have been identified in the claystones beneath the Solar Ponds, and are a potential migration pathway for contaminants to leave the Solar Ponds area Fractures have also been identified in two boreholes to the north of the Solar Ponds and in several boreholes within the northeastern portion of the ITS A seismic refraction study was conducted in the Solar Ponds and North Walnut Creek areas during 1995 (DOE 1995) and analysis of this data indicated that the upper 10 to 30 feet of the claystone bedrock is weathered The deepest weathering is found along the North Walnut Creek drainage

Siltstone

Based on the DOE 1995 report, siltstone subcrops have been identified within the study area of this SAP (Figure 3) Siltstone subcrops beneath the northern portions of the central Solar Pond and extend toward the northwest for approximately 300 feet Another siltstone subcrop, approximately 100 feet wide and 1300 feet long, was identified roughly paralleling the western section of North Walnut Creek The siltstones are brown to light yellowish brown and commonly contain horizontal bedding with manganese and iron oxide staining (DOE 1995)

Sandstone

Both weathered and unweathered sandstone was identified within the study area (Figure 3) Most of the sandstones area composed of very fine-to medium fine-grained, subangular to subrounded, poorly- to moderately-sorted, sand that commonly contains appreciable amounts of silt and clay The sandstones are thinly to thickly interbedded and interlaminated with discontinuous siltstones or silty claystones The lateral extent of the sandstone is larger than what is delineated by borehole control and extends west beyond the northwestern edge of western Solar Pond (DOE 1995) Data collected during the DOE 1995 study indicates that the sandstone thins and nearly crops out in localized areas on the hillside north of the central and eastern Solar Ponds

Groundwater flow in the weathered bedrock mimics that in the alluvium The hydraulic conductivity of the weathered bedrock is one to two orders of magnitude less than that in the alluvium Localized fracturing in the claystone and siltstone, as well as the presence of the sandstone lenses provide potential preferential groundwater flow pathways for contaminant migration between the stratigraphic units

Competent Bedrock

The competent bedrock at RFETS consists of claystone which is relatively unfractured and generally contains little water The lateral ground water flow direction in the competent bedrock is not well defined, as it is difficult to install wells in which water levels can be measured The hydraulic conductivity of the competent bedrock is one to two orders of magnitude less than that of the weathered bedrock

1 3 3 Groundwater Recharge in the SPP Area

Groundwater recharge in the SPP area comes primarily from runoff from the Protected Area, particularly the Building 779 area and from water used for dust suppression for the Solar Ponds RMRS/RTG (1997) estimated that approximately 35 % (or about 1 million gallons) of the water collected by the ITS resulted from infiltration of surface runoff from Building 779

1.3.4 Incised Bedrock Channels and Preferential Flow Paths

Buried incised bedrock channels and ridges are present at the base of the alluvium and are shown on Figure 3 Five incised bedrock surface channels are interpreted to be within the study area (DOE 1995) These incised channels are significant because they represent preferential flow paths for ground water and contaminants A topographic high in the bedrock surface beneath the central and eastern Solar Ponds causes part of the groundwater from this area to flow to the north toward North Walnut Creek and part of the groundwater to flow to the southeast and east toward South Walnut Creek The incised bedrock channels will affect the flow of subsurface fluids, as they generally contain more permeable material than the surrounding bedrock (sand and sandy gravel material versus claystone)

2.0 PROJECT AND DATA QUALITY OBJECTIVES

This section presents the project objectives, data quality objectives, and specifics of the proposed analytical program

2.1 Project Objectives

The primary objective of the groundwater sampling event outlined in this SAP is to determine the nature and extent of the SPP during low flow season (late fall/early winter) and high flow season (spring) and identify potential contaminant sources This data will be used to

- Refine the site conceptual model
- Develop a groundwater flow model for evaluation of the fate and transport of site contaminants
- Evaluate the impacts of the retained alternatives on North Walnut Creek

A secondary objective is to evaluate the amount and distribution of uranium present in the groundwater and to estimate what quantity of this uranium is attributable to RFETS activities

2 2 Data Quality Objectives

Data requirements to support this project were developed using criteria established in *Guidance for the Data Quality Objective Process*, EPA QA/G-4 (EPA 1994) The data gaps, study boundaries, and decisions are described below

Groundwater action levels are specified in RFCA (DOE 1996) and are intended to prevent contamination of surface water by applying action levels to groundwater which are protective of surface water and ecological resources These groundwater action levels are based on maximum contaminant levels (MCLs) and applied using a two-tiered approach Tier I action levels are 100 x MCLs and are designed to identify sources of groundwater contamination that should be addressed through accelerated actions Tier II action levels consist of MCLs and are designed to prevent surface water from exceeding surface water standards by triggering groundwater management actions when necessary

The groundwater sampling events outlined in this SAP focus on evaluating the groundwater quality of the three stratigraphic units (alluvium, weathered bedrock, competent bedrock) in the Solar Ponds, SPP, North Walnut Creek and South Walnut Creek areas The data to be collected under this SAP will be used to attain the objectives listed below

- Characterization of alluvial and bedrock hydrogeological systems and their interactions (will be accomplished through refinement of the site conceptual hydrogeologic model and development of a groundwater flow model)

- Delineation of upgradient sources of contamination to SPP (will be accomplished by analysis of 11 samples in the western portion of the Solar Ponds for volatile organic compounds and analysis of a sample from P114389, which is in the North Walnut Creek drainage upgradient of the SPP)

- Characterization of the water quality in SPP groundwater

- Evaluation of fate and transport of uranium and nitrate in SPP, this will include a flowpath analysis and a determination of the mass flux of contaminants to North Walnut Creek (will be accomplished by including the effects of water quality data into the groundwater flow model)

- Evaluation of the effectiveness of the retained alternatives in protecting North Walnut Creek (will be accomplished by simulating the effects of each retained alternative on the SPP and North Walnut Creek using the groundwater model)

- Evaluation of the quantity of uranium added to the SPP by site activities (will be evaluated by sampling and evaluation of uranium isotope analyses of background wells and comparison of uranium isotope ratios between background and SPP wells)

2.2.1 Basis for Selection of SPP Wells for Sampling

Prior to selection of SPP wells to be sampled under this SAP, it was necessary to determine which wells contained sufficient water for sample collection It was anticipated that many wells might not contain enough water for sample collection because the initial sampling event was planned for the low flow season (late fall/early winter) and some wells are located in or near areas which are typically unsaturated during this time of year

The RMRS sampling crew visited each well in the SPP area to determine if it still existed and if it contained enough water for collection of nitrate and uranium sample aliquots Based on this information, 65 wells within the SPP were selected for sampling in the initial sampling event These 65 wells were distributed across the Solar Ponds, SPP, North Walnut Creek and South Walnut Creek areas and included wells screened in all three stratigraphic units (alluvium, weathered bedrock, and competent bedrock) Some wells near the Solar Ponds were screened across the alluvium and weathered bedrock, these wells were also selected for sampling The 65 wells represent all but three of the wells in the SPP which contained sufficient water for sample collection These three wells were omitted from this sampling program due to their proximity to wells selected for the program and the overlap of their screened intervals Evaluation of the locations and screened intervals of the dry wells indicated that data from these wells was not necessary for complete characterization of the SPP For this reason, wells not included in the initial sampling event will not be checked for water and sampled during subsequent water level or sampling events under this SAP

Although these wells will give a good picture of the water quality in each stratigraphic unit, installation of additional wells is necessary in several areas where wells are not present, contain too little water for full sample collection (due to very small casing/screen diameters), or have been destroyed Five new monitoring wells will be installed across three areas southeast of the MSTs (Areas 1) and to the southeast of the Solar Ponds (Areas 2 and 3) The new wells are intended to monitor specific zones within the Upper Hydrostratigraphic Unit (UHSU) (alluvium or weathered bedrock) and will help to identify any stratification of contaminants within the UHSU See Figures 1 and 2 for locations of existing wells to be sampled and the Areas where the proposed new monitoring wells will be installed

One well will be installed in the alluvium of Area 1 to provide water quality data near North Walnut Creek downgradient of the ITS system Two wells were originally proposed for this area, but review of the well distribution in the area indicated that only one additional well would be necessary to fully characterize the area One well also will be installed in the alluvium to the southeast of the southeastern Solar Pond (Area 2) Although a well currently exists in this area, the well is very small diameter and will not yield enough water for the sample aliquots Three wells will be installed in the weathered bedrock of Area 3 to characterize the water quality The alluvium is dry in this area and no wells which can be sampled exist in this area Five wells were originally proposed for this area, however, there are not many suitable drilling sites in this area The proposed well locations were redistributed such that three wells will provide water quality data for this area

Wells will be installed at all five proposed locations, even if the target formation does not appear to be saturated during drilling Site experience has shown that it often takes several days for the wells to fill with water If a sample cannot be collected during the low flow season, the well will be revisited during the high flow season and a sample collected if sufficient water is present

Once the results of the initial sampling event are reviewed, six to ten wells representing the stratigraphic units will be selected for two additional rounds of sampling The data from these sampling events will more clearly define the nature and extent of the Solar Ponds Plume, any seasonal variation in the water quality in the stratigraphic units, and allow evaluation of the necessity of a groundwater management action for the SPP

2.2 2 Data Quality Objectives for Uranium Data

The uranium isotopic data collected during this investigation will be used for three purposes These purposes and the DQO associated with each are identified in Table 3

The samples collected for uranium analysis under this SAP will be filtered in the field, thus the results of the laboratory analyses will yield dissolved uranium activities Because all samples will be bailed (no wells are equipped with low-flow pumps), RFETS feels that this data will represent the most mobile uranium in the groundwater system—the dissolved and colloidal fractions Analyzing bailed samples for total uranium activity may report the uranium activity of the sediment entrained in the water bailed from the well, not the water that is moving through the aquifer The results of the dissolved uranium analyses from the initial sampling event will be reviewed and compared to the historic dissolved and total uranium data available for

Table 3. Purposes and Data Quality Objectives for Uranium Isotopic Data

Purpose of Uranium Isotopic Data	Data Quality Objective
Characterize the extent and activity of uranium isotopes within the stratigraphic units of the SPP	Samples will be analyzed by alpha spectroscopy, this data will indicate the presence of uranium in the groundwater within the SPP Data will also be used to calculate ratio of U^{238} to U^{235} for evaluation of the source of uranium (naturally occurring or from RFETS activities)
Verify the results of evaluation of uranium isotopic data generated by alpha spectroscopy Specifically, verification of data interpretation in areas within and near the edge of the SPP that appear to have predominately naturally-occurring uranium	An additional sample will be collected from these wells and analyzed for uranium isotopes by the more accurate and precise inductively coupled plasma/mass spectroscopy (ICP/MS) method The calculation of the ratio of U^{238} to U^{235} resulting from this data will be of sufficient accuracy to confirm the source of the uranium observed in the groundwater
Confirm that the uranium found in background wells is, in fact, attributable to naturally-occurring uranium and allow correlation between the results of alpha spectroscopy analyses with the more accurate ICP/MS analyses	Eight background wells representing a range of uranium isotope activities will be sampled and the samples analyzed for uranium isotopes by both alpha spectroscopy and ICP/MS This data, collected from a statistically-significant number of wells, will be used to construct a correlation curve between uranium isotope data generated from the two analytical methods

these wells If a large difference between the dissolved and total uranium activities is observed, both filtered and unfiltered samples may be collected from the six RFCA wells in the SPP during the next SPP sampling event to evaluate this difference

<u>**Evaluation of Site Contribution to Dissolved Uranium in SPP**</u>

As discussed in detail in Section 2 3 1, the source (naturally occurring or RFETS activities) can be identified by calculating the ratio of the number of atoms of U^{238} to U^{235} To provide high quality uranium isotope data comparable to the data to be collected from the SPP wells, 14 background wells and five wells in the North and South Walnut Creek drainages outside of the SPP were selected for sampling during the initial sampling event (shown on Figure 1) The background wells were selected to represent the three stratigraphic units (alluvium, weathered bedrock, competent bedrock) and because background uranium activities vary greatly across RFETS, a range of uranium isotope activities

Two wells were selected for sampling in both the North and South Walnut Creek drainages One well in each drainage is located near the first retention pond and the other is located near the last retention pond, these data points will allow evaluation of changes in uranium activity as the water travels down the drainage The third well selected for sampling in the North Walnut Creek drainage is P114389 (Figure 1), this well will provide water quality information regarding the water entering the North Walnut Creek drainage from upgradient of the SPP Please see Section 2 3 1 for a thorough discussion of the planned sampling activities and uranium isotope data evaluation

2.3 Proposed Sampling Activities

Sixty-five existing wells will be sampled and five new groundwater monitoring wells will be installed and sampled for nitrate/nitrite and uranium isotopes to identify the extent of the SPP Eleven of the existing wells also will be analyzed for volatile organic compounds (VOCs) to evaluate upgradient sources of VOC contamination Nineteen existing wells not considered part of the SPP (five in North and South Walnut Creek drainages and 14 background wells) also will be sampled (See section 2 2 for discussion of selection of these wells) Eighteen of these wells will be analyzed for uranium isotopes only, one well (P144389) in the North Walnut Creek drainage upgradient of the SPP area will be analyzed for both uranium isotopes and nitrate/nitrite to evaluate the water quality entering the SPP from upgradient The wells to be sampled are shown on Figures 1 and 2 and described on Table 1

The initial sampling event (all 89 wells) was planned for late fall 1997/early winter 1998, during the low flow season for groundwater at RFETS In order to complete the sampling event during this season, it was necessary to begin sampling in November 1997 The initial sampling event will be completed in early February 1998

The new groundwater monitoring wells will be installed and sampled in February 1998 Once the results of this initial sampling event have been reviewed, six to ten wells will be selected for two more sampling events, which will define high flow groundwater conditions at RFETS The samples will also be analyzed for nitrate/nitrite and uranium isotopes Water levels from all 65 wells (or 70 wells if the new wells have been installed) will be measured in one event in February 1998, and water levels will be measured at a subset (15 wells) of these wells monthly through June 1998

Table 1 lists the wells to be sampled, the unit screened by the wells, and the analyses requested for each well for the initial sampling event Table 2 presents the analytical methods and sampling requirements for the initial sampling event

The initial sampling event will include the following parameters

- 65 existing wells and the five new wells will be analyzed for nitrate/nitrite and uranium isotopes because these are the primary contaminants of the SPP (70 wells total)

- 19 additional wells (5 in North and South Walnut Creek drainages and 14 background wells) will be sampled Eighteen will be analyzed for uranium isotopes only, one well, located upgradient of the SPP in the North Walnut Creek drainage, will be analyzed for both uranium isotopes and nitrate/nitrite

- 11 of the existing 65 wells within the SPP will be sampled for volatile organic compounds (VOCs) to evaluate the extent of the VOC plumes which originate outside of the Solar Ponds area

Table 1 Wells To Be Sampled In November 1997 - February 1998

	Geologic Unit	Well #	Nitrate/Nitrite and Uranium	Uranium Only	VOCs	Comments
1	Alluvium	05293	Y	---	---	
2	Alluvium	2686	Y	---	---	
3	Alluvium	3887	Y	---	---	
4	Alluvium	05193	Y	---	---	
5	Alluvium	P209789	Y	---	---	
6	Alluvium	P218389*	Y	---	---	
7	Alluvium	P207889	Y	---	---	
8	Alluvium	05093	Y	---	---	
9	Alluvium	5687	Y	---	---	
10	Alluvium	2286	Y	---	---	
11	Alluvium	45793	Y	---	Y	
12	Alluvium	41193	Y	---	---	
13	Alluvium	46293	Y	---	---	
14	Alluvium	45093	Y	---	---	
15	Alluvium	45393	Y	---	---	
16	Alluvium	46393	Y	---	---	
17	Alluvium	1386*	Y	---	---	
18	Alluvium	1586	Y	---	---	
19	Alluvium	1786*	Y	---	---	
20	Alluvium	29795	Y	---	---	
21	Alluvium	B208589	Y	---	---	
22	Alluvium	B210489*	Y	---	---	
23	Alluvium	B208789*	Y	---	---	
24	Alluvium	10594	---	Y	---	North Walnut Creek
25	Alluvium	10694	---	Y	---	North Walnut Creek
26	Alluvium	75292	---	Y	---	South Walnut Creek
27	Alluvium	75992 or 3686	---	Y	---	South Walnut Creek
28	Alluvium	P114389	Y	---	---	North Walnut Creek
29	Alluvium	B205589**	---	Y	---	Background
30	Alluvium	B200589	---	Y	---	Background
31	Alluvium	B202589	---	Y	---	Background
32	Alluvium	B102289**	---	Y	---	Background
33	Alluvium	B302789**	---	Y	---	Background
34	Alluvium	10294	---	Y	---	Background
35	Alluvium	5386**	---	Y	---	Background
36	Alluvium	5586	---	Y	---	Background
37	Alluvium	Area 1, W1	Y	---	---	Area 1, New Well
38	Alluvium	Area 2, W1	Y	---	---	Area 2, New Well

Table 1. Continued

	Geologic Unit	Well #	Nitrate/Nitrite and Uranium	Uranium Only	VOCs	Comments
39	Alluvium/Bedrock	45893	Y	---	Y	
40	Alluvium/Bedrock	45993	Y	---	Y	
41	Alluvium/Bedrock	41993	Y	---	Y	
42	Alluvium/Bedrock	42993	Y	---	---	
43	Alluvium/Bedrock	43593	Y	---	---	
44	Alluvium/Bedrock	43893	Y	---	Y	
45	Alluvium/Bedrock	43993	Y	---	Y	
46	Alluvium/Bedrock	42393	Y	---	Y	
47	Alluvium/Bedrock	41693	Y	---	---	
48	Alluvium/Bedrock	43293	Y	---	---	
49	Weathered Bedrock	28295	Y	---	---	
50	Weathered Bedrock	B208689	Y	---	---	
51	Weathered Bedrock	B210389	Y	---	---	
52	Weathered Bedrock	P210089	Y	---	---	
53	Weathered Bedrock	30595	Y	---	Y	
54	Weathered Bedrock	30695	Y	---	Y	
55	Weathered Bedrock	29395	Y	---	Y	
56	Weathered Bedrock	45693	Y	---	Y	
57	Weathered Bedrock	46193	Y	---	---	
58	Weathered Bedrock	P209889	Y	---	---	
59	Weathered Bedrock	26995	Y	---	---	
60	Weathered Bedrock	P209589	Y	---	---	
61	Weathered Bedrock	3086	Y	---	---	
62	Weathered Bedrock	P208989	Y	---	---	
63	Weathered Bedrock	P209489*	Y	---	---	
64	Weathered Bedrock	P209189	Y	---	---	
65	Weathered Bedrock	P210189	Y	---	---	
66	Weathered Bedrock	P209089	Y	---	---	
67	Weathered Bedrock	05393	Y	---	---	
68	Weathered Bedrock	P207989	Y	---	---	
69	Weathered Bedrock	76292	Y	---	---	
70	Weathered Bedrock	P219589	Y	---	---	
71	Weathered Bedrock	23995	Y	---	---	
72	Weathered Bedrock	02691	Y	---	---	
73	Weathered Bedrock	Area 3, W1	Y	---	---	Area 3, New Well
74	Weathered Bedrock	Area 3, W2	Y	---	---	Area 3, New Well
75	Weathered Bedrock	Area 3, W3	Y	---	---	Area 3, New Well
76	Weathered Bedrock	B203189**	---	Y	---	Background
77	Weathered Bedrock	B305389**	---	Y	---	Background

78	Weathered Bedrock	B201589**	---	Y	---	Background
79	Weathered Bedrock	B203489	---	Y	---	Background
80	Weathered Bedrock	B405489**	---	Y	---	Background
81	Bedrock	B304989	---	Y	---	Background
82	Bedrock	P208889	Y	---	---	
83	Bedrock	3987	Y	---	---	
84	Bedrock	1486	Y	---	---	
85	Bedrock	3286	Y	---	---	
86	Bedrock	2386	Y	---	---	
87	Bedrock	2586	Y	---	---	
88	Bedrock	2786	Y	---	---	
89	Bedrock	1686	Y	---	---	

* RFCA Well
** U by ICP/MS

Table 2. Analytical Sampling Requirements

Analytical Method	Number of Samples	Number of QC Samples	Total Number of Samples	Containers, Preservatives, Holding Times
EPA Method 524 2 Volatile Organic Compounds	11	1 duplicate 1 rinsate 2 trip blanks	15	Three 40 ml teflon-lined VOA vials with septum lids, HCl to pH < 2 and 4° C, 14 days
EPA Method 353 2 Nitrate/Nitrite as Nitrogen	71	4 duplicates 4 rinsates	79	250 ml in polyethylene jar, H_2SO_4 to pH<2, 4° C, 28 days
Alpha Spectroscopy Dissolved Uranium Isotopes	89	5 duplicates 5 rinsates	99	One 1-L glass bottle, 4°C, 6 months
Inductively Coupled Plasma/ Mass Spectroscopy Dissolved Uranium Isotopes	8	1 duplicate 0 rinsate	9	One 1-L glass bottle, 4°C, 6 months
Radiological Screening	89	0 duplicates	99	100 ml in poly jar, delivered to on-site lab next day

The wells to be sampled and the analytes to be requested in the additional sampling events will be determined after review of the results of the initial sampling event

2 3.1 Uranium Isotope Analyses

All wells will be sampled for dissolved uranium isotopes by alpha spectroscopy during the initial sampling event By sampling all 89 wells (the 65 existing SPP wells, five new SPP wells, five wells in North and South Walnut Creek drainages, and 14 background wells) for uranium isotopes and using the same analytical technique, the data will be comparable with historical data collected from these locations

An evaluation of the likely source of the uranium seen in the SPP groundwater (naturally occurring or attributable to the site) will be conducted by calculating the ratio of the number of atoms of U^{238} to U^{235} from the uranium isotope data collected during this sampling event In naturally-occurring uranium, this ratio is approximately 138 Samples containing enriched uranium resulting from site activities would be expected to have ratios significantly below 138, samples containing depleted uranium would be expected to have ratios significantly above 138

Because alpha spectroscopy has an accuracy of approximately 80%, it may not be possible to define the uranium in a sample as attributable to naturally-occurring uranium in all instances To help understand these situations, eight background samples will also be analyzed for uranium isotopes by another analytical method, EPA Method 6020, ICP/MS For analysis of uranium isotopes with low activity, a preconcentration step is added to the method ICP/MS has greater precision than alpha spectroscopy and an accuracy of approximately 95 to 99% This method provides the mass, rather than the activity, of the uranium isotopes

The eight wells selected for analysis by both methods (ICP/MS and alpha spectroscopy) consist of four wells in the alluvium and four wells in the weathered bedrock These wells have a range of concentrations from very low to relatively high (for background wells) Comparison of the ratios calculated from samples analyzed by both methods should allow development of a correlation curve for the alpha spectroscopy data obtained from the other wells The DQO for these samples was discussed in Section 2 2 2

ICP/MS may also be used to verify the results of evaluation of uranium isotopic data generated by alpha spectroscopy An additional sample may be collected from wells located in areas within and near the edge of the SPP that appear to have predominately naturally-occurring uranium or from wells which indicate a source of uranium different from that of the wells in the surrounding area If necessary, these samples would be collected during the April or June sampling events and analyzed for uranium isotopes by ICP/MS At least one sample of the ITS water will be analyzed for uranium isotopes by ICP/MS The DQO for these samples was discussed in Section 2 2 2

2.3.2 Analysis of Metals Data

No samples will be analyzed for metals during this sampling event A thorough analysis of all of the metals data available for the SPP wells was conducted Metals data existed for 11 wells (1386, 1486, 1586, 1786

76292, B208589, B208689, B210389, B210489, P209789, and P209889) which covered the Solar Ponds and SPP area The results of this analysis are summarized below

- No metals were detected above the Tier II action levels (MCLs) or background (mean plus two standard deviations or M2SD) for four wells (1486, 1786, B210389, and 76292)

- Thallium above the site background of 4 9 µg/L was sporadically detected in five wells (1586, B208589, B208689, P209789, and P209889), but there did not appear to be a trend of increasing concentrations at these wells, nor did adjacent wells have high thallium concentrations

- Cadmium above the Tier II level (5 µg/L) was detected at 1386 in 1992, however, the 1993 concentration was below the Tier II level and site background (4 25 µg/L) At B209889, cadmium concentrations in samples collected in 1991 and 1993 exceeded the Tier II level The cadmium concentration in the 1995 sample (3 8 µg/L) was below both the Tier II level and the M2SD

- Nickel above the Tier II level was detected in the November 1996 sample from 1386 Trend analysis of the nickel data for 1991 through 1996 shows that the data bounces up and down every other sampling event, no trend is apparent High nickel concentrations were not observed in any other SPP wells

- Strontium above the Tier II level was detected fairly consistently at P209889 from 1991 through April 1994 However, strontium concentrations in samples collected from October 1994 through July 1995 were below the Tier II level Strontium above the Tier II level was not detected at any downgradient wells

- Lithium was consistently detected at concentrations above the MCL at both well B208689 and P209889 Both of these wells are in the center of the SPP and indicate that the lithium has moved with the groundwater in the weathered bedrock from the Solar Ponds to the North Walnut Creek area However, samples from the alluvial well adjacent to B208689 near North Walnut Creek (1786) showed no metals above the MCL Therefore, it does not appear that the lithium is entering the alluvium and the surface water of North Walnut Creek

Based on the above summary of data, there is no indication of a metals plume in the SPP groundwater which requires additional sampling to characterize The only metal of potential concern is lithium, and wells in the alluvium along North Walnut Creek downgradient of B208689 are part of the RFCA program and are monitored biannually (1786, B210489, and 1386) If lithium is detected above the Tier II level in these wells, sampling of additional wells for lithium may be required All of the metals data will be provided to the subcontractor who will be developing the site conceptual hydrogeologic model and the groundwater flow model to ensure that they are considered in all geochemical interpretations The lithium data, in addition to the nitrate/nitrite and uranium data, will be provided to the subcontractor evaluating the phytoremediation system

2.3.3 Measurement of Eh in SPP Wells

Downhole Eh measurements will be collected in some SPP wells to evaluate the redox potential in the groundwater of the various stratigraphic units at these locations The downhole Eh probes at RFETS are relatively large diameter, therefore, only wells with a 4-inch diameter will be considered for these measurements Alternatively, a flow-through cell and Eh probe may be used for measurement of smaller diameter wells All of the wells installed within the SPP area in 1989 (well names end in "89") are 4-inch diameter This includes six wells in the alluvium, 12 wells in the weathered bedrock, and one competent bedrock well Seventeen wells distributed in the three stratigraphic units across the SPP were selected for monthly water level measurements, six of these (P219589, P218389, P208989, P210089, B210389, and B208589) are 4-inch diameter Eh measurements will be collected in from these wells during the March and May water level measurement events This data will provide additional information to be used in evaluation of the retained remedial alternatives

3.0 WELL INSTALLATION, SAMPLING AND ANALYSES

This SAP has been designed to collect the data necessary to define the SPP and allow selection and implementation of a groundwater control system, if the SPP hydrogeological analysis and groundwater flow model indicate that one is necessary A thorough definition of the SPP will require installation of five new wells in three areas of the SPP (Areas 1, 2, and 3, as shown on Figure 2) Two wells are planned to be installed in the alluvium and three in the weathered bedrock, depending upon the saturated thickness in the Areas Three of the wells will be installed in the Protected Area to the southeast of the Solar Ponds

The sampling requirements for the samples to be collected under this SAP are described in Table 2 and in the following sections Samples will be handled in accordance with FO 10 Receiving, Labeling, and Handling Environmental Material Containers, and FO 13 Containerization, Preserving, Handling and Shipping of Soil and Water Samples If conditions are encountered in the field which make the use of a procedure unsafe or inappropriate for the task at hand, the specified procedures may be modified or replaced as long as the modification or replacement procedure is justified and detailed in the field logbook, and the resulting data is comparable and adequate to meet the objectives of the project

3.1 Well Installation Using Geoprobe™

Each well location will be established using tape and compass, and marked with reference stakes or flags and a unique number for that location The well location number will be obtained from RFEDS (or the Soil Water Database) and correlated with sample analyses for that location These locations will be surveyed for location and elevation using GPS receivers operated in accordance with the equipment manuals (Ashtech 1993)

The Geoprobe™ will be used to advance the boreholes for well installation Core will be collected continuously in 2- to 5-foot increments from the surface to the depth required for proper screening of the well in the targeted stratigraphic unit, as determined by the on-site geologist For alluvial wells, total well depth will be approximately 2 feet into bedrock or weathered bedrock The on-site geologist will determine the depth of the weathered bedrock wells by identifying the water level in the weathered bedrock during borehole advancement and continuing to drill until a sufficient saturated thickness for well installation or until competent bedrock is encountered The core will be monitored in accordance with FO 15 Photoionization Detectors and Flame Ionization Detectors, visually inspected for signs of contaminant staining, and then lithologically logged by the field geologist per GT 01 Logging Alluvial and Bedrock Material No soil samples will be collected for chemical analysis The core will be added to the RFETS core library

3.2 Groundwater Samples

After the boreholes are completed to the required depth, the wells will be installed Well construction will consist of threaded, 1-inch internal diameter, Schedule 80 PVC casing and screen and a threaded PVC bottom cap The well casing will reach 6 inches or more above the ground surface 16/40 filter sand will be poured around the PVC screen and will extend to at least 1 foot above the top of the screen The remaining well annulus will be filled with bentonite to prevent surface runoff from entering the well annulus Granular bentonite will be poured into the annular space in 2- to 3-foot increments Water will be added to swell the bentonite before the next increment is poured This process will continue to ground surface A 1 5-foot section of 2-inch internal diameter casing will be installed around the above-ground section of the well casing A slip-over PVC cap will be loosely placed on the well casing and a threaded PVC cap will be placed on the 2-inch diameter protective casing

A sample will be collected from the well using the methods specified in GW 06 Groundwater Sampling, if sufficient water is present (estimated as at least 1 foot of standing water) The water level will be measured prior to and after collection of the groundwater sample, according to GW 01 Water Level Measurements in Wells and Piezometers All water level measurements will be recorded in the project logbooks The well will be allowed to recover for at least one day prior to water level measurement and sampling

4.0 DATA MANAGEMENT

A field logbook will be created and maintained for the project by the project manager or her designee in accordance with ER-ADM-05 14 Use of Field Logbooks and Forms The logbook will be used in conjunction with the appropriate field data forms required by the operating procedures (Table 4) governing the field activities occurring during this project It is not necessary to duplicate items recorded on field data forms in the field notebook, but if additional clarification of entries on the forms is required, they should be recorded in the field notebook The field notebook should include time and date information concerning the field activities and a sketch map of actual sample locations Information not specifically required by the field data forms should be recorded in the field notebook Data for this project will be collected, entered, and stored in a secure, controlled, and retrievable environment in accordance with 2-G18-ER-ADM-17 01 Records Capture and Transmittal

4.1 Project Completion

The results of the each sampling event will be compiled into a data summary report with a map showing well locations The results of the sampling events will help define the nature and extent of the SPP and will be used by the hydrogeology and phytoremediation subcontractors to evaluate the three retained remedial alternatives for the SPP (RMRS/RTG 1997) Data interpretation will be conducted by the hydrogeology subcontractor and will be summarized in the Decision Document by RMRS

Table 4. Applicable Field and Administrative Standard Operating Procedures

Procedure Number	Procedure Title
2-G18-ER-ADM-17 01	Records Capture and Transmittal
2-G32-ER-ADM-08 02	Evaluation of ERM Data for Usability in Final Reports
2-S47-ER-ADM-05 14	Use of Field Logbooks and Forms
5-21000-OPS-FO 3	General Equipment Decontamination
5-21000-OPS-FO 6	Handling of Personal Protective Equipment
5-21000-OPS-FO 7	Handling of Decontaminated Water and Waste Water
5-21000-OPS-FO 10	Receiving, Labeling, and Handling Environmental Material Containers
5-21000-OPS-FO 11	Field Communications
5-21000-OPS-FO 13	Containerization, Preserving, Handling and Shipping of Soil and Water
5-21000-OPS-FO 15	Photoionization Detectors and Flame Ionization Detectors
5-21000-OPS-FO 16	Field Radiological Measurements
5-21000-ER-OPS-GT 01	Logging Alluvial and Bedrock Material
5-21000-ER-OPS-GT 06	Monitoring Wells and Piezometer Installation
5-21000-ER-OPS-GT 39	Push Subsurface Soil Sampling
5-21000-ER-OPS-GW 01	Water Level Measurements in Wells and Piezometers
5-21000-ER-OPS-GW 06	Groundwater Sampling

4.2 Quality Assurance

Analytical data collected in support of this investigation will be evaluated using the guidance established by the Rocky Flats Administrative Procedure 2-G32-ER-ADM-08 02, Evaluation of ERM Data for Usability in Final Reports This procedure establishes the guidelines for evaluating analytical data with respect to precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters

Precision for this project will be evaluated by calculating the relative percent difference between samples and duplicates (30% will be used for an acceptable RPD) and laboratory and field replicates will be analyzed at a rate of 1 in 20

Accuracy for the project will be evaluated by analyzing Laboratory Control Samples, method blanks and equipment blanks at a rate of 1 in 20 The laboratory QC data associated with some historical alpha spectroscopy data (for analysis of uranium isotopes) has sometimes failed to meet the frequency agreed upon among RFETS, CDPHE, and EPA RFETS has established new laboratory contracts in the last year and these laboratories are being monitored to ensure that appropriate laboratory QC is conducted and provided to RFETS Review of the recent laboratory packages submitted under the new contracts indicates that the laboratories are conducting the appropriate laboratory QC and providing the data to RFETS For this reason, RFETS expects the alpha spectroscopy data to be collected under this SAP will meet all QC requirements previously agreed to

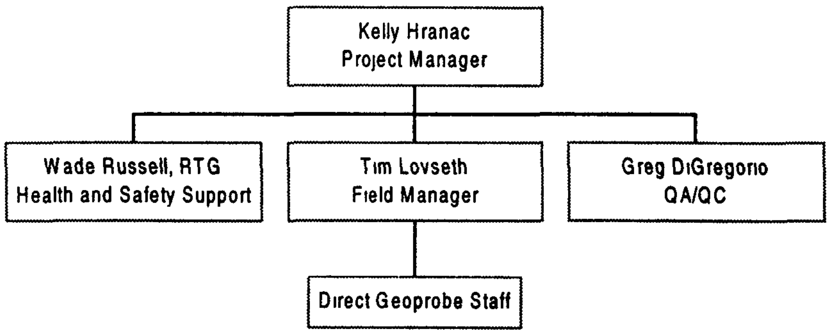
Representativeness will be ensured by following the applicable approved sampling procedures and workplans and ensuring that the chains of custody documents are properly completed Comparability of historical and new data will be ensured by use of the same analytical methods and by documenting/referencing all analytical procedures Completeness will be evaluated by comparing the proposed to the actual field program The target for completeness for the project is 90%

One hundred percent (100%) of the electronic data will be verified for holding times, relative percent difference, etc Twenty-five percent (25%) of the hard copy data will be validated

5.0 PROJECT ORGANIZATION

The project organization chart is presented in Figure 4 The ER Projects Group is responsible for management and coordination of resources dedicated to the project Other organizations assisting with the implementation of this project are RMRS Groundwater, RMRS Health and Safety, and RMRS Quality Assurance

Figure 4 Project Organization



7 0 LIST OF ACRONYMS

DOE	Department of Energy
DQO	Data Quality Objective
EPA	Environmental Protection Agency
ER	Environmental Restoration
GPS	Global Positioning System
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
MCLs	Maximum Contaminant Levels
OU	Operable Unit
QA/QC	Quality Assurance/Quality Control
QAPD	Quality Assurance Program Description
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services
SAP	Sampling and Analysis Plan
SPP	Solar Ponds Plume
UHSU	Upper Hydrostratigraphic Unit
VOCs	Volatile organic compounds

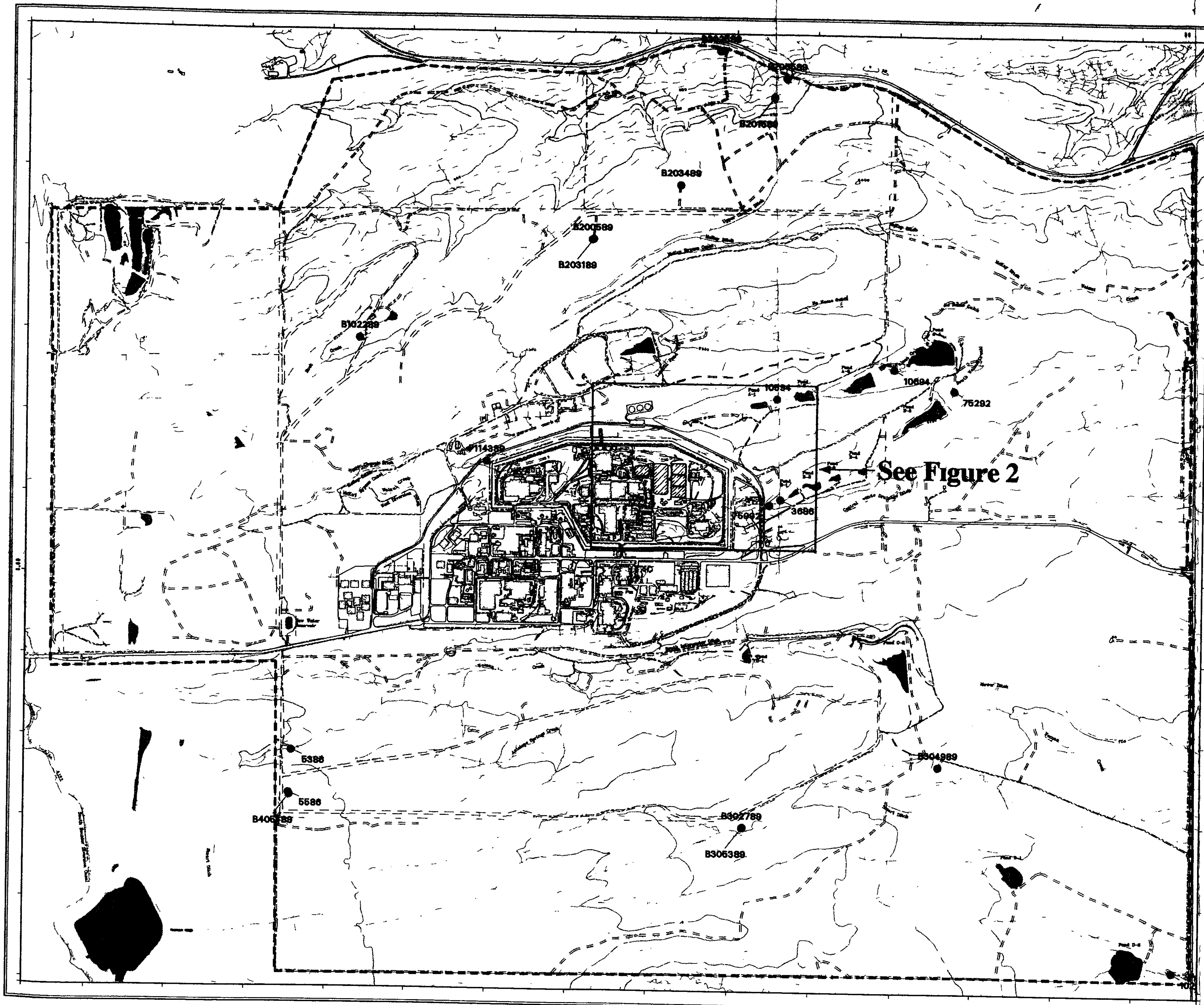


Figure 1

Groundwater Well Location Map

EXPLANATION

Legend

- UHSU Bedrock Monitoring Well
- Alluvium Monitoring Well

Standard Map Features

- Building and other structures
- Solar evaporatio pond
- Lake and pond
- Streams, ditches, other drai age feat res
- Fences and other barrier
- Contour (20-Foot)
- Rocky Flats boundary
- Paved roads
- Dirt road

Scale = 1 20450
1 in h represents approximately 1704 feet

500 0 1000 2000ft

Stat Plan Coordi ate Projectio
Colorado Central Zone
Dat m NAD27

U S Department of Energy
Rocky Flats Environmental Technology Site

Prepared by

RMRS Rocky Mountain Remediation Services, L.L.C

MAP ID: MK

January 21 1998

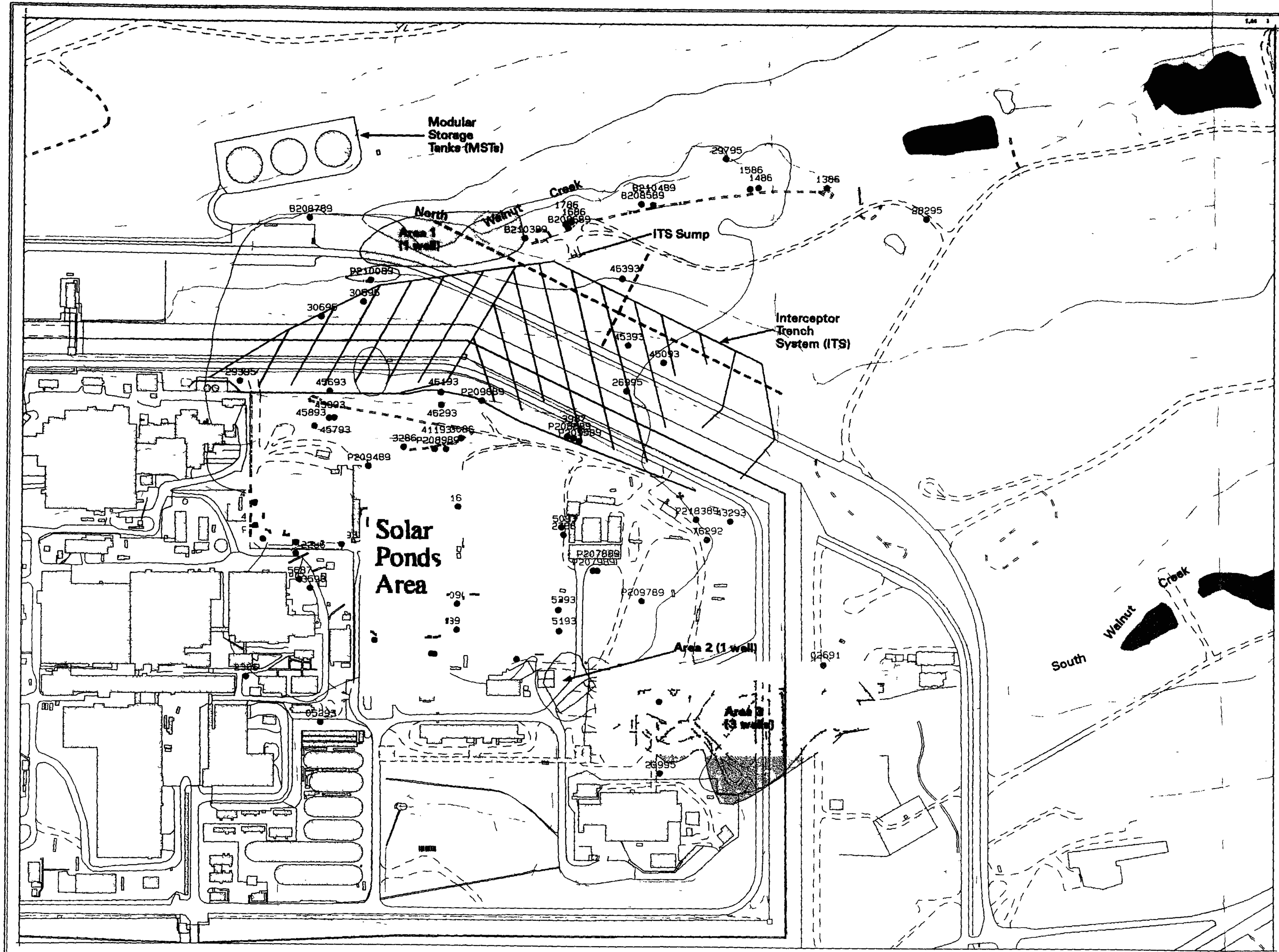


Figure 2
Groundwater Well Location Map
Solar Evaporation Ponds Area and Vicinity

EXPLANATION

- Transects for Collection of Soil Samples
- LHSU Bedrock Monitoring Well
- UHSU Bedrock Monitoring Well
- Bedrock/Alluvium Monitoring Well
- Alluvium Monitoring Well
- General Locations of New Weathered Bedrock Geoprobe Well
- General Locations of New Alluvium Geoprobe Wells (if water is present during drilling)
- Approximate Extent of SPP Nitrate Plume (MCL)

Standard Map Features

- Buildings nd other structures
- Sola evaporation pond
- Lake nd pond
- Streams, ditches, or other drainage feature
- Fence nd the barriers
- Contour (20-Foot)
- Paved road
- Dirt road

Scale 1 3860
1 inch represents pproximately 322 feet

0 200 400

State Plane Coordinate Projectio
Colorado Central Z ne
Datum NAD27

U S Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain R mediation Services L.L.C

MAP ID 98-0071

January 22, 1998

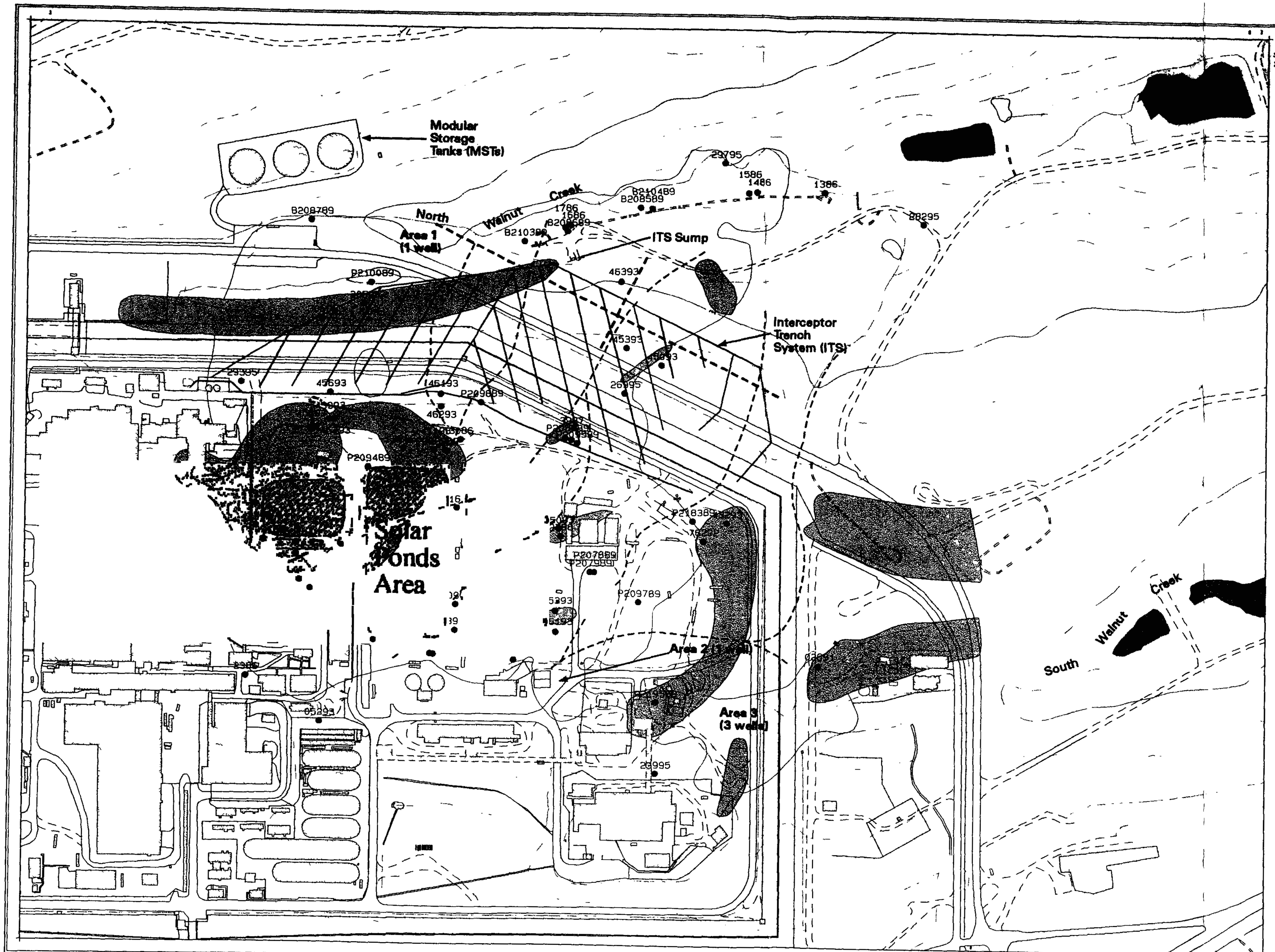


Figure 3

Subcrop Lithology and Bedrock Channel Axis Map

Solar Evaporation Ponds Area and Vicinity

EXPLANATION

- LHSU Bedrock Monitoring Well
- UHSU Bedrock Monitoring Well
- Bedrock/Alluvium Monitoring Well
- Alluvium Monitoring Well
- Transects for Collection of Soil Samples
- Bedrock Channel Axi
- Approximate Extent of SPP Nitrate Plume (MCL)
- Subcropping Sandstone
- Subcropping Siltstone

All rea not marked sandstone siltone re claystone

Standard Map Feature

- Building nd othe structure
- Sola evaporation pond
- Lakes nd pond
- Stream ditches, or othe dra nage feature
- Fence d the barriers
- Contour (20-Foot)
- Paved road
- Dirt road

N

Sc le 1 3860
1 inch represe ts approximately 322 feet

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St te Plan Coordinate Projectio
Colorado Ce tr l Zone
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January 29, 1998